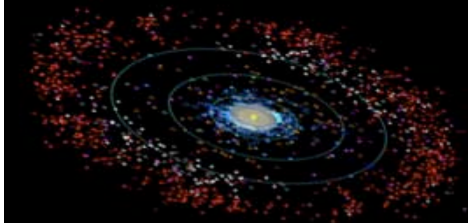
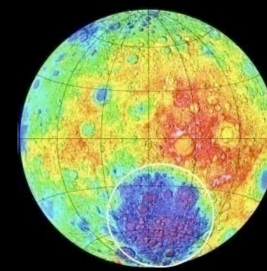
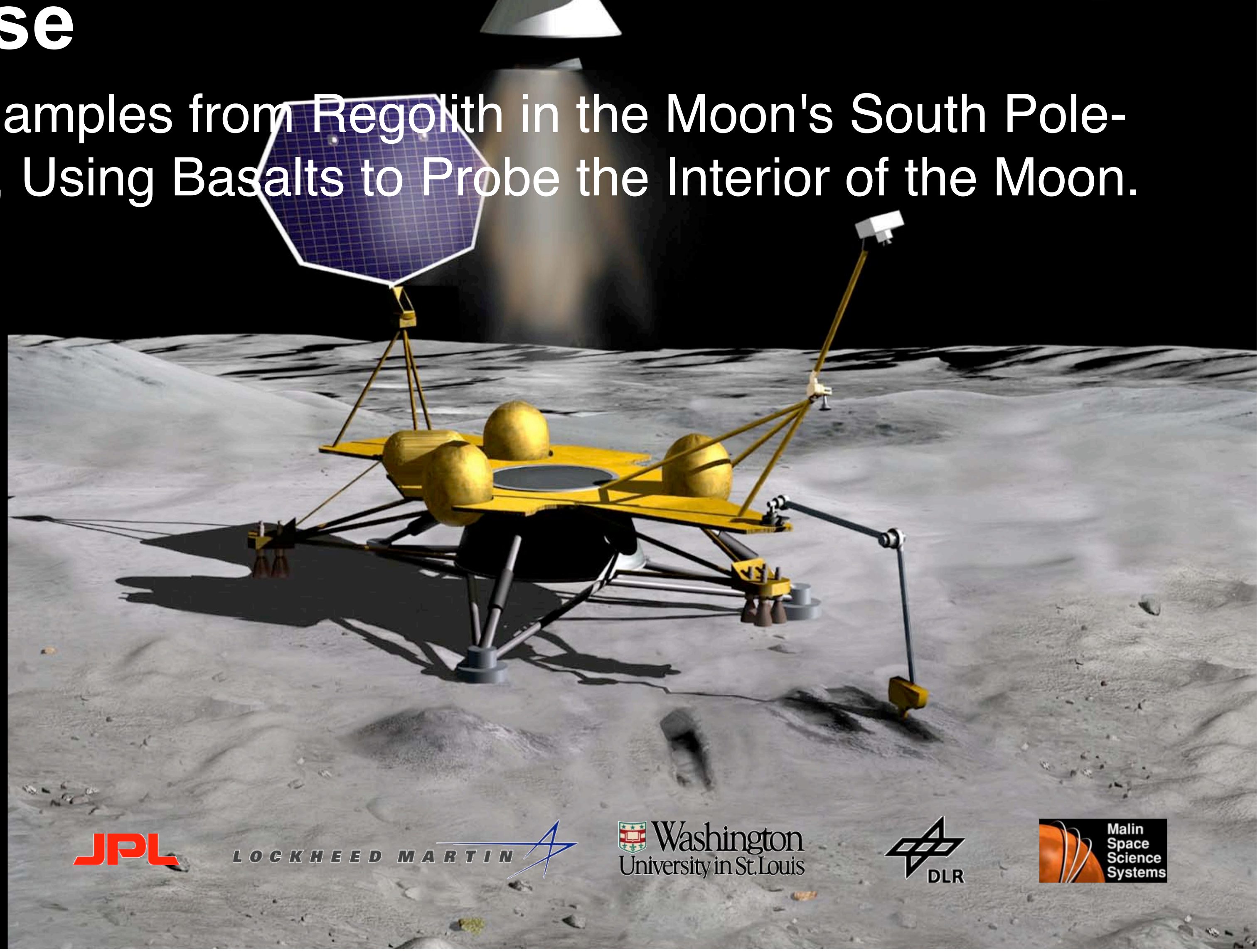




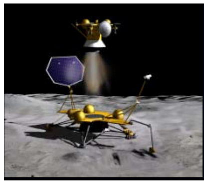


MoonRise

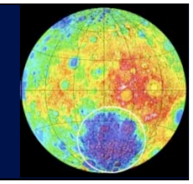
Analysis of Samples from Regolith in the Moon's South Pole-Aitken Basin, Using Basalts to Probe the Interior of the Moon.

Charles Shearer
Bradley Jolliff
Lars Borg
Dimitri Papanastassiou
Lisa Gaddis
James Head
Harald Hiesinger
Gary Lofgren
Marc Norman
Justin Hagerty

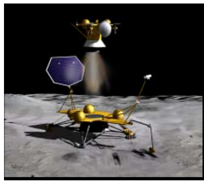
JPL · LOCKHEED MARTIN · Washington University in St. Louis · DLR · Malin Space Science Systems



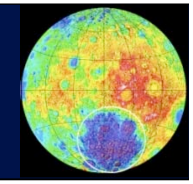
Summary of MoonRise Talks at the Lunar Forum



- MoonRise sample return from the South Pole-Aitken Basin. Jolliff et al., Poster
- Re-determining Rb-Sr ages of Apollo 16 impact melt rocks: Implications for sample return from SPA. Papanastassiou et al., Talk July 21, 3:45 pm
- Geologic context for lunar sample return: The MoonRise context imager. Jaumann et al., Poster
- Compositional diversity in the South Pole-Aitken Basin (SPA) as viewed by the Moon Mineralogy Mapper (M^3). Petro et al., Talk July 22, 11:30 am
- **Analysis of samples from regolith in the Moon's South Pole-Aitken Basin, Using basalts to probe the interior of the Moon. Shearer et al., Talk July 21, 3:30 pm**



MoonRise



- **Determines the age of a key event in Solar System history.**
  - Test of the Cataclysm hypothesis for early bombardment of Earth-Moon System
  - Test of hypotheses for early orbital dynamics of gas giant planets
  - * **MoonRise tests these hypotheses by determining the age of the oldest impact melts and thus the age of the SPA Basin formation.**

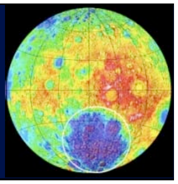
Artist's concept of formation of the South Pole-Aitken Basin

William K. Hartman

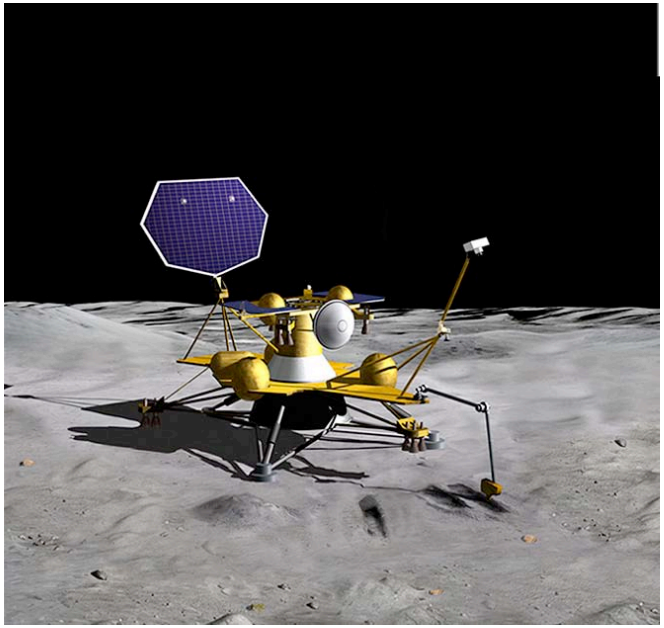
Solar System relevance:

- **Test models of orbital dynamics in the early Solar System**
- **What caused the release of small orbiting bodies to the Inner Solar System?**
- **What were the effects on the development of habitable environments and life on Earth?**

MoonRise Mission Overview

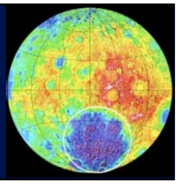


- **2016: MoonRise launches on an EELV to the Moon.**
- **The Lander will descend into the interior of the South Pole-Aitken Basin on the Moon's far side, while a dedicated satellite provides communications.**
- **On the surface, MoonRise scoops and sieves a volume of soil near the lander to collect thousands of rock fragments.**
  - Rocks are well mixed and representative of the surrounding basin.

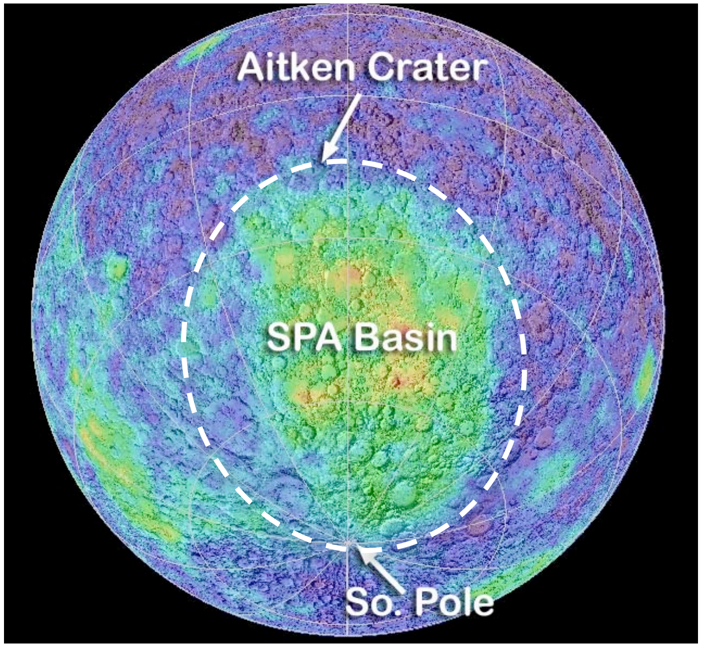


- **Sample materials are transferred to the sample return canister (SRC).**
- **Ascent Vehicle launches from the Moon and returns the SRC to Earth where it is recovered at the Utah Test Range and transported to the NASA/JSC Curatorial Facility.**
  - Rocks returned to Earth for age determinations and other analyses in state-of-the-art laboratories.
- **MoonRise samples are available for study by scientific community worldwide and for many years into the future.**

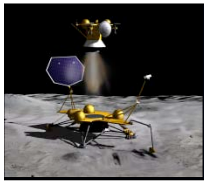
MoonRise Goals address three broad Planetary Science issues



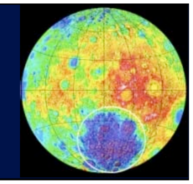
1) Impact history of inner Solar System
   - <u>Test Cataclysm Hypothesis</u>
   - Illuminate first 500 million years of Solar System history
2) Large basin impact events and effects
   - <u>Understand basin formation processes</u>
   - What is their role in the evolution of planetary surfaces?
3) **Interior differentiation of planetary bodies**
   - **<u>Learn how planetary crusts and mantles formed</u>**



Moon uniquely preserves a record of these events in its rocks and regolith.



Issue 3. Interior differentiation of planetary bodies



1) EXPLAIN

- Learn how planetary crusts and mantles formed

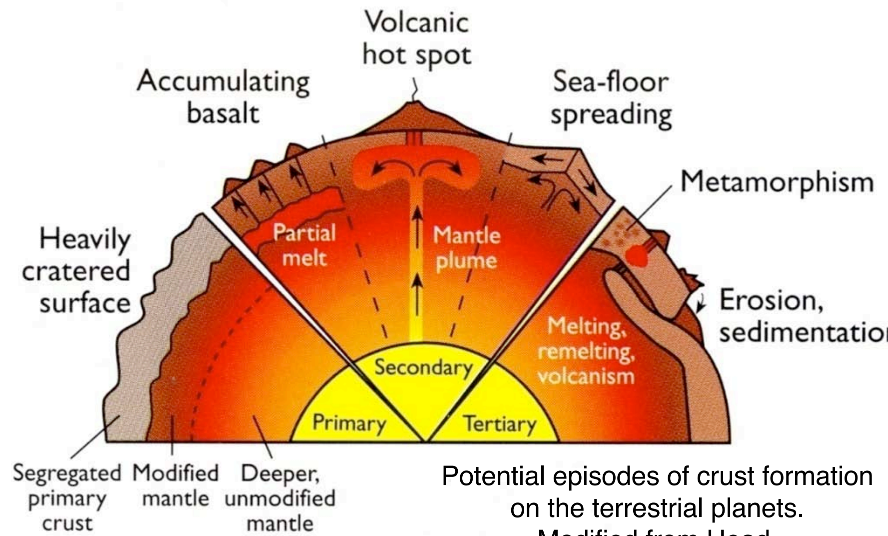
2) WHY?

- Link between crustal-asymmetry and the mantle

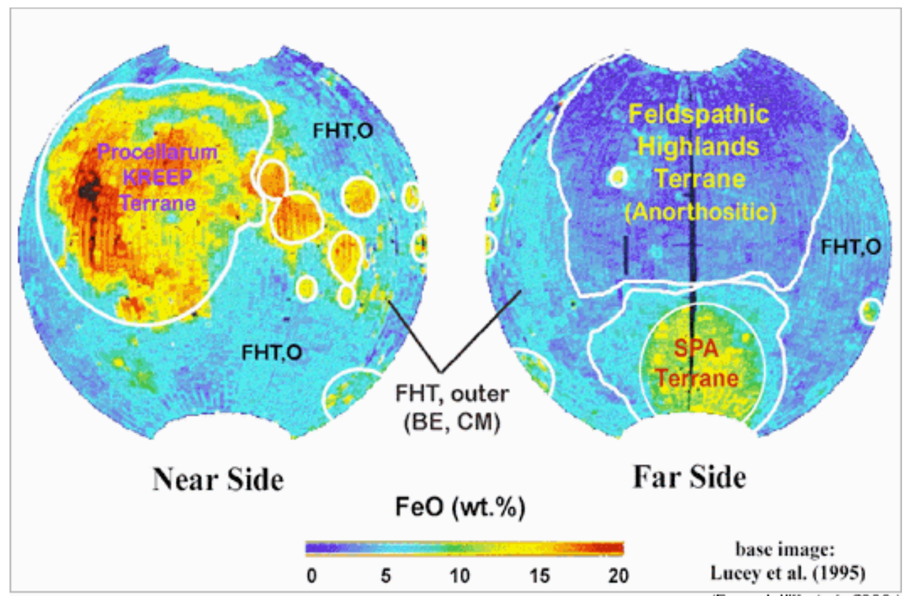
3) APPROACH

- Explore new crustal terrains unique to SPA
- Decipher the distribution of Th
- Use basalts as probes of the lunar interior

Remnants of primary and secondary crust are preserved on the Moon.



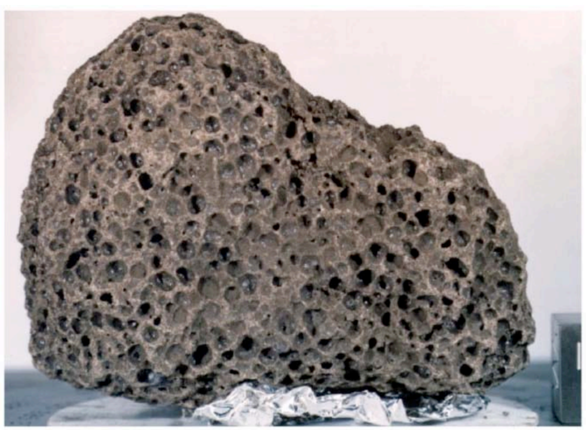
Potential episodes of crust formation on the terrestrial planets.
Modified from Head

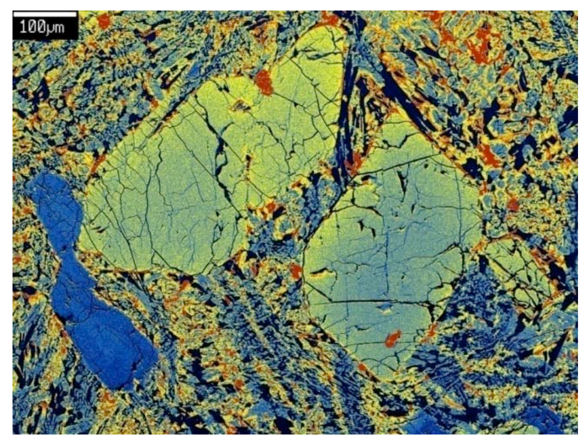


(From Jolliff *et al.*, 2000.)

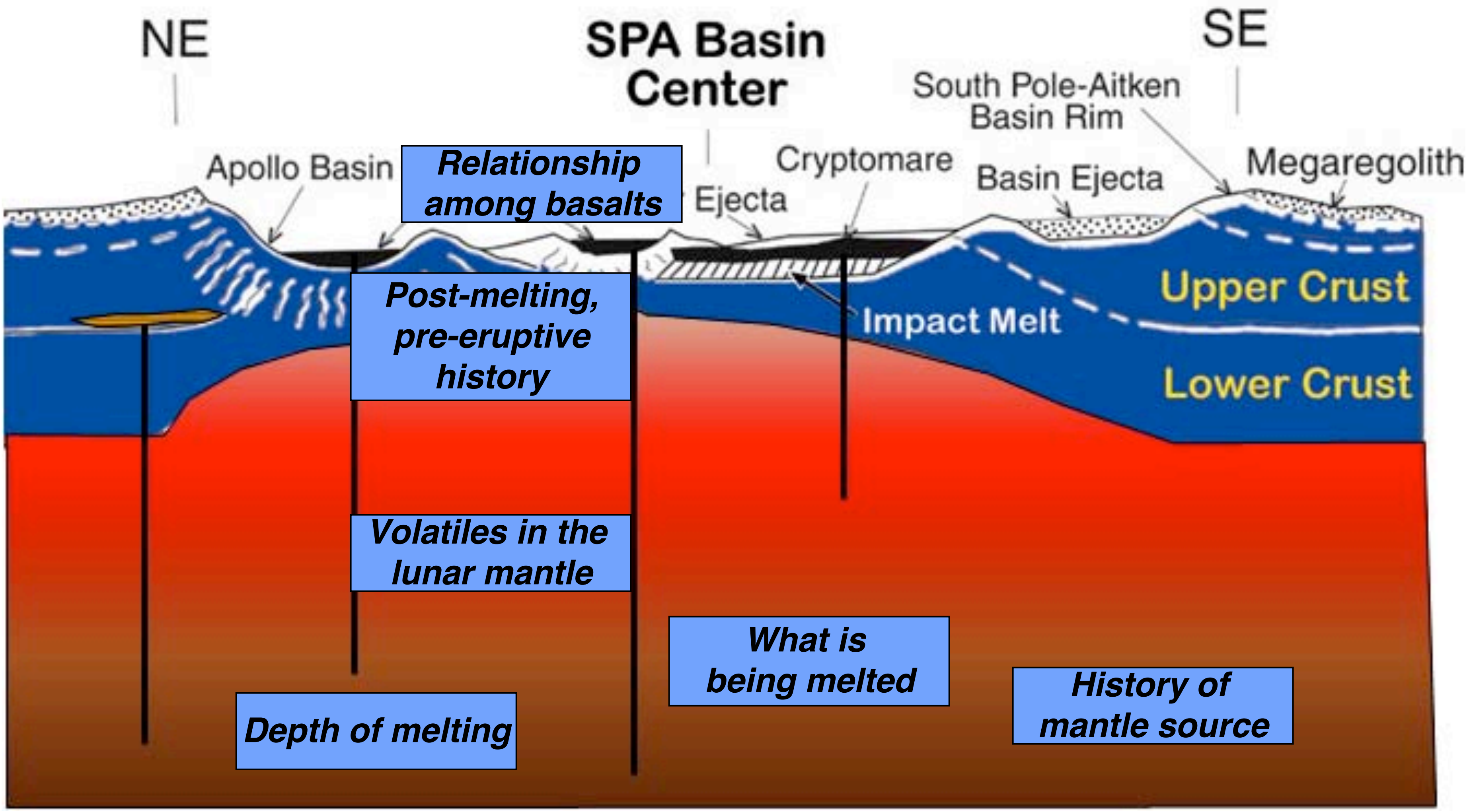
Basalts as probes of planetary interiors

Basalts are products of melting of planetary interiors.
The characteristics of basalts represent their mantle sources, dynamics of the mantle, the melting process, and transport-eruptive mechanisms.

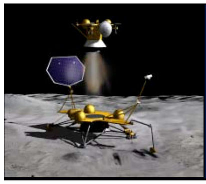




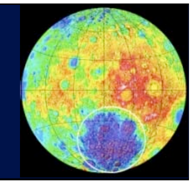
Basalts as probes of planetary interiors



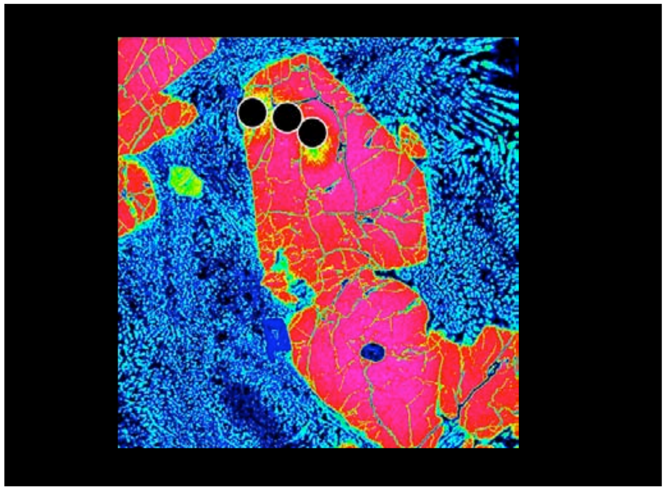
Modified from Head (1993)



Big return on small samples
Example NWA 032



Starting sample mass: 100 mg plus thin section



Post-melting, pre-eruptive history

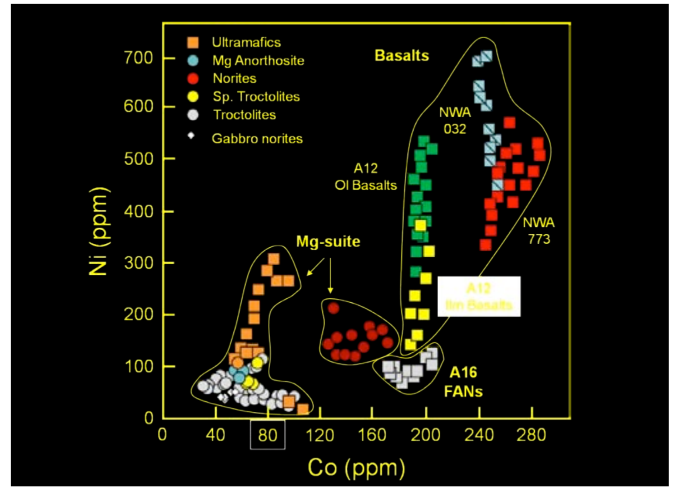
Relationship among basalts

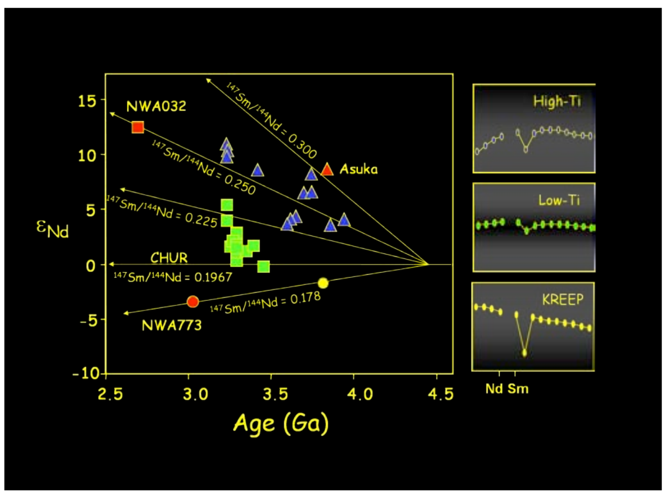
Depth of melting

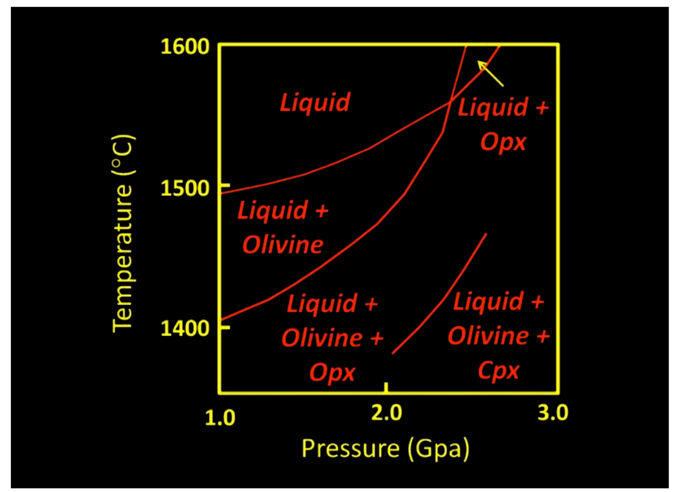
Volatiles in the lunar mantle

History of mantle source

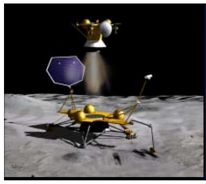
What is being melted



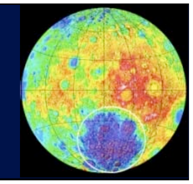




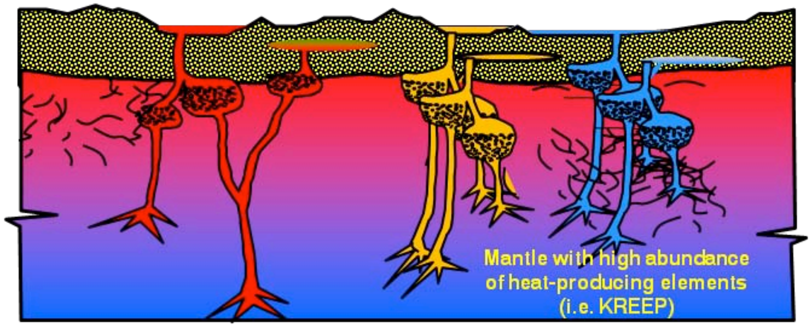
Planetary-scale perspective can be extracted from small samples due to high spatial resolution and high analytical precision currently available for analyzing planetary materials.



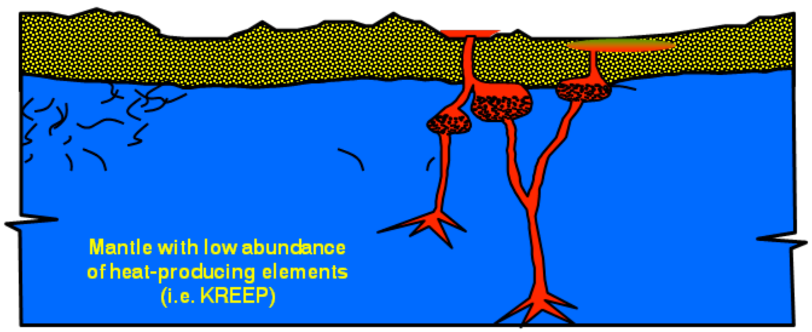
Basalts as probes
Application to SPA



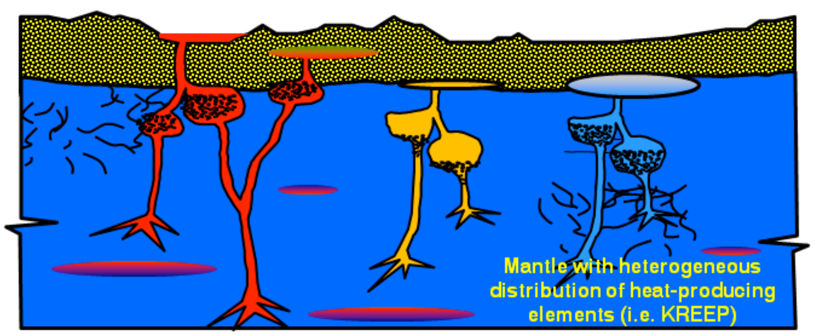
Near-side mare volcanism



Far-side mare volcanism



Far-side mare volcanism

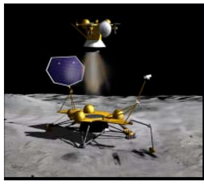


One hypothesis that MoonRise will test is that the lower abundance of far side basalt is related to lower heat production in the far side mantle due to the migration of radioactive elements (K, U, Th) toward the near side mantle and the PKT.

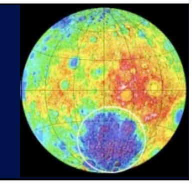
An alternative hypothesis is that the heat sources in the far side mantle are just as abundant as in the near side mantle, but lie deeper or are more diffuse than in the near side mantle, leading to differences in mantle dynamics and/or the volume of magma generated.

Both hypotheses have major implications for the primordial differentiation of the Moon, origin and nature of lateral asymmetry in the Moon's mantle and its relationship to the well-defined crustal asymmetry.

Determine ages and compositions of far-side basalts to determine how mantle source regions on the far-side of the Moon differ from regions sampled by Apollo and Luna. Assessment of these differences will provide a fundamental point of reference for understanding the earliest stages of mantle evolution for all of the terrestrial planets.

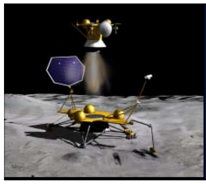


MoonRise Concluding Points

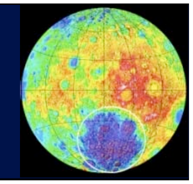


- **MoonRise achieves key Solar System Science Objectives as stated in the 2003 NRC Decadal Survey for Solar System Exploration, the NRC 2007 “NOSSE” report, and the 2007 NRC study on Scientific Context for Exploration of the Moon.**
- **In addition to testing the cataclysm hypothesis for early bombardment of the inner Solar System and the hypotheses for early orbital dynamics of gas giant planets, it has other important Solar System objectives.**
- **First sample return of basalts from the far-side of the Moon.**
  - Test models for the magmatic and thermal evolution of asymmetrical planetary bodies.
  - Tests models for the differentiation of the Moon and its relevance to the differentiation of terrestrial planets.

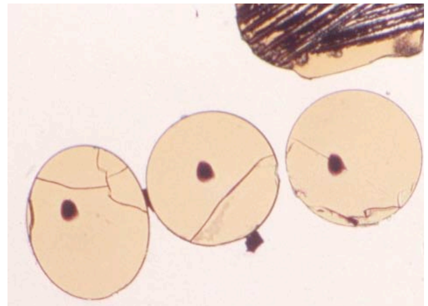
MoonRise addresses key NASA objectives for Planetary Science, specifically to advance scientific knowledge of the history and processes of the Solar System, with implications for the history of early Earth at a pivotal time in the development of its habitable environments. MoonRise addresses questions of how the Solar System evolved to its current diverse state, and how events in the Solar System led to the origin of life.



Big return on small samples



Relatively small samples often record planetary- and solar system-scale processes.

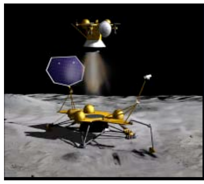


Early planetary differentiation

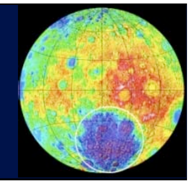
Origin of the Earth-Moon system

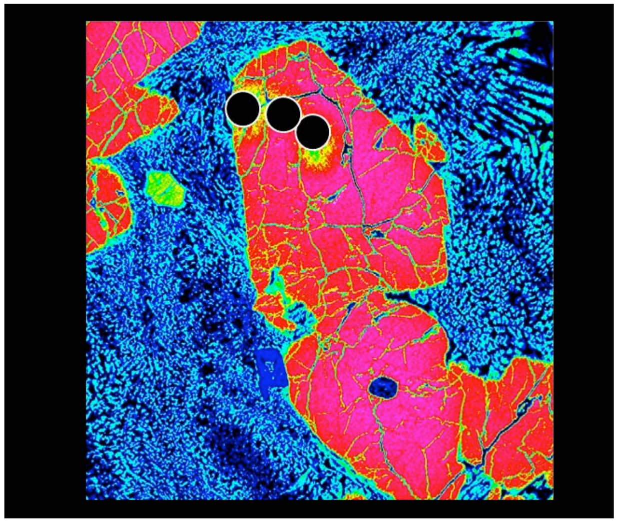
Lunar cataclysm

Planetary-scale perspective can be extracted from small samples due to high spatial resolution and high analytical precision currently available for analyzing planetary materials.



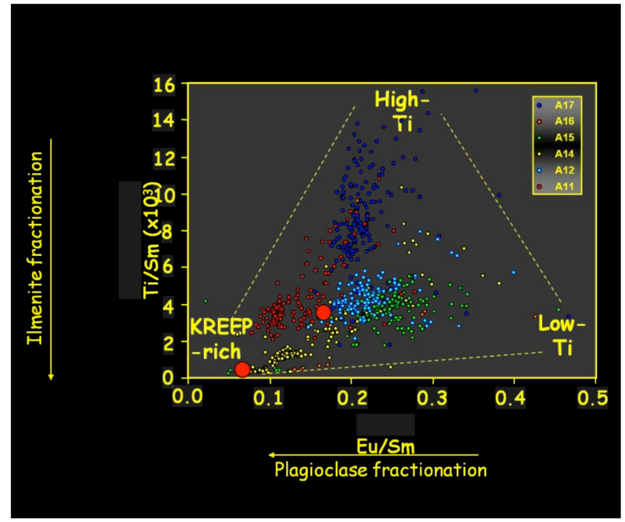
Basalts as probes of planetary interiors





Relationship among basalts

Post-melting, pre-eruptive history

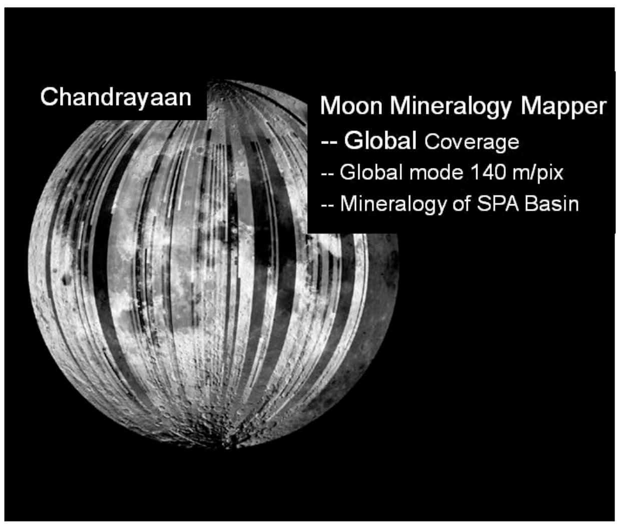


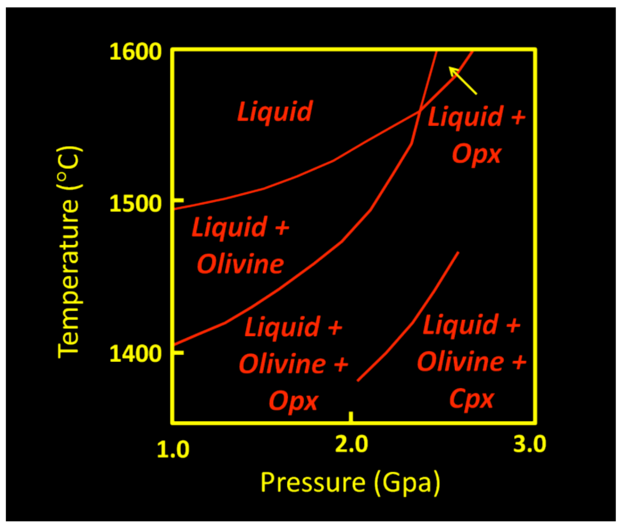
Volatiles in the lunar mantle

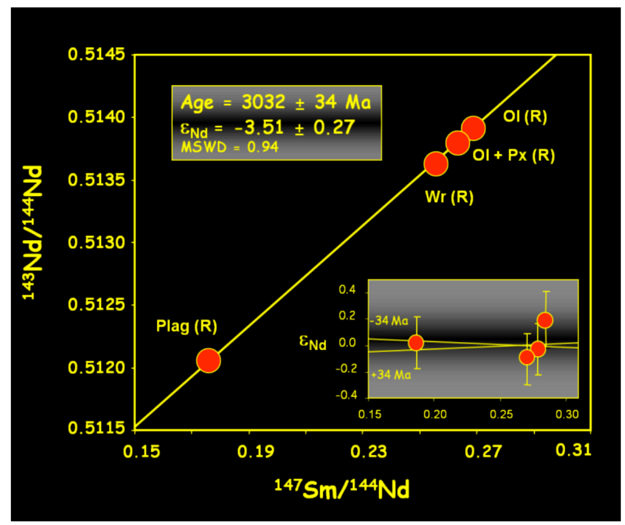
Depth of melting

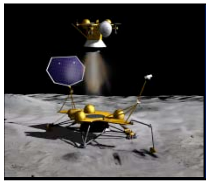
History of mantle source

What is being melted

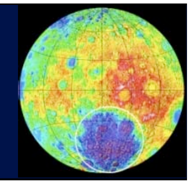








Mini-probes of planetary interiors
Example NWA 773



Starting sample mass: 100 mg plus thin section